3.0 Background Pipeline Risk Data

A number of sources are available for pipeline incident data. Unfortunately however, few of them include the reliable pipeline inventory necessary to determine meaningful incident rates. In this study, we have included results from the following sources:

- CONCAWE Oil Pipelines Management Group's Special Task Force on Pipeline Spillages (OP/STF-1). Performance of Oil Industry Cross Country Pipelines in Western Europe, Statistical Summary of Reported Spillages. 1981 to 1989 annual reports.

- Line Pipe Research Supervisory Committee of the Pipeline Research Committee of the American Gas Association. An Analysis of Reportable Incidents for Natural Gas Transmission and Gathering Lines 1970 Through June 1984, NG-18 Report Number 158. 1989.

- Line Pipe Research Supervisory Committee of the Pipeline Research Committee of the American Gas Association. An Analysis of Reportable Incidents for Natural Gas Transmission and Gathering Lines June 1984 Through 1989, NG-18 Report Number 196. 1989.

- United States Department of Transportation, Research and Special Programs Administration, Office of Pipeline Safety. Annual Report on Pipeline Safety. 1986 through 1989 annual reports.

Each of these reports provide pipeline incident data for *reportable* incidents. Unfortunately however, the criteria for *reporting* incidents differs for each study. This makes direct comparison of the individual results difficult. On the other hand, it provides a methodology for estimating incident rates for spills meeting various criteria.

The following subsections provide a summary of the data contained in each of these reports. The incident rates are shown in units of *incidents per 1,000 mile years*. This unit provides a means for predicting the number of incidents expected for a given length of line, over a given period of time. For example, if one considered an incident rate of 1.0 incidents per 1,000 mile years; one would expect one incident per year on a 1,000 mile pipeline. If the pipeline was only 1 mile long, one would expect 1/1,000th of an incident per year, or an incident every 1,000 years. Using these units, frequencies of occurrence can be calculated for any pipeline length and/or time interval.

3.1 CONCAWE - 1981 Through 1989

We have summarized the pipeline results for western European pipelines, as presented in the CONCAWE Performance of Oil Industry Cross Country Pipelines In Western Europe, Statistical Summary of Reported Spillages, 1981 through 1989 annual reports in Table 3-1.

Table 3-1
European Hazardous Liquid Pipeline Incidents
As Reported By CONCAWE
1981 through 1989

	1981	1982	1983	1984	1985
Total Pipeline Mileage	11,737	11,364	11,240	10,743	10,805
Number of Incidents	16	10	10	13	7
Incident Rate (Incidents/1,000 Mile Years)	1.36	0.88	0.89	1.21	0.65
Number of Injuries	0	0	0	0	0
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.000	0.000	0.000	0.000
Number of Fatalities	0	0	0	0	0
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.000	0.000	0.000

	1986	1987	1988	1989	Total
Total Pipeline Mileage	10,805	10,805	10,992	11,737	100,228
Number of Incidents	12	8	11	13	100
Incident Rate (Incidents/1,000 Mile Years)	1.11	0.74	1.00	1.11	1.00
Number of Injuries	0	0	0	1	1
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.000	0.000	0.085	0.010
Number of Fatalities	0	0	0	3	3
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.000	0.256	0.030

Reportable incidents include:
1. All leaks greater than one cubic meter (264 gallons or approximately 6 barrels).
2. All leaks under one cubic meter which resulted in noteworthy environmental impact.

The criteria for including hazardous liquid pipeline incidents in these reports are as follows:

·   all spills greater than one cubic meter (approximately 264 gallons or 6 barrels) and

·   spills less than one cubic meter, if the spill had a noteworthy impact on the environment.

It is interesting to note that this reporting criteria does not include any consideration for incidents which cause injuries and/or fatalities. As a result, the injury and fatality incident rates derived from this data may be low. Also, the overall incident rates for these relatively large spills is comparatively low, as shown below:

·   Incident Rate   1.00 incidents per 1,000 mile years
·   Injury Rate   0.010 injuries per 1,000 mile years
·   Fatality Rate   0.030 fatalities per 1,000 mile years

3.2   U.S. Natural Gas Transmission and Gathering Lines, 1970 Through June 1984

Table 3-2 presents the reportable domestic natural gas transmission and gathering line incidents from 1970 through June 1984. The criteria for leaks to be reported to the Department of Transportation for inclusion in this data are as follows:

·   resulted in a death or injury requiring hospitalization,
·   required the removal from service of any segment of a transmission pipeline,
·   resulted in gas ignition,
·   caused an estimated damage to the property owner, or of others, or both, of $5,000 or more,
·   involved a leak requiring immediate repair,
·   involved a test failure that occurred while testing either with gas or another test medium, or
·   in the judgement of the operator, was significant even though it did not meet any of the above criteria.

The incident rates for reported leaks meeting this criteria are summarized below:

·   Incident Rate   1.30 incidents per 1,000 mile years
·   Injury Rate   0.096 injuries per 1,000 mile years
·   Fatality Rate   0.016 fatalities per 1,000 mile years

Table 3-2
· U. S. Natural Gas Transmission and Gathering Lines
Reportable Incidents
1970 through June 1984

	1970	1971	1972	1973	1974	1975
Total Pipeline Mileage	284,196	285,482	285,575	285,241	293,885	267,079
Number of Incidents	343	409	409	471	458	366
Incident Rate (Incidents/1,000 Mile Years)	1.21	1.43	1.43	1.65	1.56	1.37
Number of Injuries	24	24	37	19	21	21
Injury Rate (Injuries/1,000 Mile Years)	0.084	0.084	0.130	0.067	0.071	0.079
Number of Fatalities	1	3	6	2	4	7
Fatality Rate (Fatalities/1,000 Mile Years)	0.004	0.011	0.021	0.007	0.014	0.026

	1976	1977	1978	1979	1980
Total Pipeline Mileage	277,555	283,373	303,355	311,098	388,857
Number of Incidents	254	445	444	482	325
Incident Rate (Incidents/1,000 Mile Years)	0.92	1.57	1.46	1.55	0.84
Number of Injuries	42	22	30	96	16
Injury Rate (Injuries/1,000 Mile Years)	0.151	0.078	0.099	0.309	0.041
Number of Fatalities	7	8	1	12	1
Fatality Rate (Fatalities/1,000 Mile Years)	0.025	0.028	0.003	0.039	0.003

	1981	1982	1983	1984 (3)	Total
Total Pipeline Mileage	400,243	342,645	346,355	157,921	4,512,860
Number of Incidents	389	390	473	204	5,862
Incident Rate (Incidents/1,000 Mile Years)	0.97	1.14	1.37	1.29	1.30
Number of Injuries	6	41	25	11	435
Injury Rate (Injuries/1,000 Mile Years)	0.015	0.120	0.072	0.070	0.096
Number of Fatalities	6	10	2	2	72
Fatality Rate (Fatalities/1,000 Mile Years)	0.015	0.029	0.006	0.013	0.016

Notes:
1. 36 of the total 72 fatalities were to employees of the operating company.
2. 161 of the total 274 injuries were to employees of the operating company.
3. The 1984 mileage figure shown is one-half the actual mileage to account for only one-half year of data.

Reportable incidents include:
1. Resulted in a death or injury requiring hospitalization.
2. Required the removal from service of any segment of a transmission pipeline.
3. Resulted in gas ignition.
4. Caused an estimated damaged to the property of the operator, or of others, or both, of $5,000 or more.
5. Involved a leak requiring immediate repair.
6. Involved a test failure that occurred while testing either with gas or another test medium.
7. Or, in the judgement of the operator, was significant even though it did not meet any of the above criteria.

3.3   U.S. Natural Gas Transmission and Gathering Lines, June 1984 through 1988

Table 3-3 presents the reportable domestic natural gas transmission and gathering line incidents from June 1984 through 1988. It is important to note that in June 1984, the Department of Transportation changed the criteria for reporting leaks. The most significant change was that in general, leaks causing less than $50,000 property damage, did not have to be reported. Since this value is significantly greater than the $5,000 criteria for the earlier study period, we see a significant decrease in the resulting *reportable* incident rate. Although impossible to verify using this data, we also believe that the actual frequency of incidents decreased during this period as a result of one-call system implementation, among other things.

The criteria for leaks to be reported to the Department of Transportation from June 1984 through 1988 were as follows:

- Events which involved a release of gas from a pipeline, or of LNG or gas from an LNG facility, which caused: (a) a fatality, or personal injury necessitating inpatient hospitalization; or (b) estimated property damage, including costs of gas lost by the operator, or others, or both, of $50,000 or more.

- An event which resulted in an emergency shut-down of an LNG facility.

- An event that was significant, in the judgement of the operator, even though it did not meet the criteria above.

The incident rates for reported leaks meeting this criteria from June 1984 through 1988 are summarized below:

- Incident Rate   0.27 incidents per 1,000 mile years
- Injury Rate   0.062 injuries per 1,000 mile years
- Fatality Rate   0.015 fatalities per 1,000 mile years

As demonstrated by the approximately 80% reduction in the incident rate over the earlier period, we see that the change in reporting criteria, among other things, had a major influence on the results. However, it is interesting to note that the injury and fatality rates remained nearly unchanged from the earlier period.

Table 3-3
Onshore U. S. Natural Gas Transmission and Gathering Lines
Reportable Incidents
June 1984 through 1988

	1984[1]	1985	1986	1987	1988	Total
Total Pipeline Mileage	157,921	324,426	340,202	290,176	310,079	1,422,804
Number of Incidents	60	115	67	60	81	383
Incident Rate (Incidents/1,000 Mile Years)	0.38	0.35	0.20	0.21	0.26	0.27
Number of Injuries	30	12	18	15	13	88
Injury Rate (Injuries/1,000 Mile Years)	0.190	0.037	0.053	0.052	0.042	0.062
Number of Fatalities	7	6	6	0	3	22
Fatality Rate (Fatalities/1,000 Mile Years)	0.044	0.018	0.018	0.000	0.010	0.015

Notes:
1. The 1984 mileage figure shown is one-half the actual mileage to account for only one-half year of data.

Reportable incidents include:
· Events which involve a release of gas from a pipeline, or of LNG or gas from an LNG facility, which cause
   (a) a fatality, or personal injury necessitating inpatient hospitalization; or
   (b) estimated propoerty damage, including costs of gas lost by the operator or others, or both, of $50,000 or more.
· An event which results in an emergency shut-down of an LNG facility.
· An event that is significant, in the judgement of the operator, even though it did not meet the criteria of 1 or 2 above.

3.4 U.S. Hazardous Liquid Pipeline Accidents, 1986 through 1989

As noted earlier, a reliable pipeline inventory is necessary to determine precise incident rates. The degree of accuracy of the domestic hazardous liquid pipeline inventory is questionable. For example, the total reported pipeline length remained constant for each year examined. However, we are aware of new line construction and line abandonments during this period. As a result, *we believe that the incident rates derived using the reported pipeline lengths are approximations only*; they should not be taken as absolute.

Table 3-4 presents the reportable domestic hazardous liquid pipeline incidents from 1986 through 1989. The criteria for incidents to be reported to the Department of Transportation for inclusion in this data were as follows:

- explosion or fire not intentionally set by the operator,
- loss of more than 50 barrels of liquid or carbon dioxide,
- escape to the atmosphere of more than five barrels per day of highly volatile liquid,
- death of any person,
- bodily harm to any person resulting in loss of consciousness, necessity to carry the person from the scene, or disability which prevents the discharge of normal duties or the pursuit of normal activities beyond the day of the accident, and/or
- estimated property damage to the property of the operator, or others, or both, exceeding $5,000.

The approximate incident rates for reported leaks meeting this criteria are summarized below:

- Incident Rate   1.30 incidents per 1,000 mile years
- Injury Rate.   0.177 injuries per 1,000 mile years
- Fatality Rate   0.018 fatalities per 1,000 mile years

It's interesting to note that these results are essentially the same as those for reportable U.S. natural gas lines from 1970 through June 1984, which had a similar $5,000 property damage reporting requirement.

Table 3-4
U. S. Hazardous Liquid Pipeline Accidents
Reportable Incidents
1986 through 1989

	1986	1987	1988	1989	Total
Total Pipeline Mileage	150,000	155,000	155,000	155,000	615,000
Number of Incidents	203	237	196	161	797
Incident Rate (Incidents/1,000 Mile Years)	1.35	1.53	1.26	1.04	1.30
Number of Injuries	32	20	19	38	109
Injury Rate (Injuries/1,000 Mile Years)	0.213	0.129	0.123	0.245	0.177
Number of Fatalities	3	3	2	3	11
Fatality Rate (Fatalities/1,000 Mile Years)	0.020	0.019	0.013	0.019	0.018

Notes:
1. The mileage figures are approximate as reported by the U.S. Department of Transportation's,
   Annual Report on Pipeline Safety, published for each subject year.

After October 21, 1985, reportable incidents include:
· Explosion or fire not intentionally set by the operator.
· Loss of more than 50 barrels of liquid or carbon dioxide.
· Escape to the atmosphere of more than five barrels per day of highly volatile liquid.
· Death of any person.
· Bodily harm to any person resulting in loss of consciousness, necessity to carry the person from the scene, or
   disability which prevents the discharge of normal duties or the pursuit of normal activities beyond the day
   of the accident.
· Estimated property damage to the property of the operator or others, or both exceeds $5,000.

3.5   Summary California Regulated Hazardous Liquid Pipeline Data - 1981 through 1990

As noted earlier, this study included all regulated California hazardous liquid pipelines.   The systems included in this study had complete leak records. *All leaks, regardless of size, extent of property damage, or extent of injury were included in the study.*   As a result, the incident rates were much higher than presented in earlier studies, which only included reported leaks fitting a relatively narrow criteria.   A summary of these results is included in Table 3-5.   The incident rates for *all* leaks during the study period are summarized below:

·	Incident Rate (All Leaks)	7.08 incidents per 1,000 mile years
·	Incident Rate (> $5,000)	5.33 incidents per 1,000 mile years
·	Incident Rate (> $50,000)	4.43 incidents per 1,000 mile years
·	Incident Rate (> $500,000)	2.80 incidents per 1,000 mile years
·	Injury Rate (any severity)	0.685 injuries per 1,000 mile years
·	Fatality Rate	0.042 fatalities per 1,000 mile years

3.6   Comparison of Various Incident Data Sources

Table 3-6 demonstrates the differences that various reporting criteria have on the resulting incident rates. It should be noted that the California incident rates, which appear to be much higher, are the only data which have been completely audited. In addition, as mentioned several times previously, the California data includes *all leaks and injuries, regardless of spill size or injury severity.* These data do *not* necessarily indicate that California's regulated hazardous liquid pipeline network presents a higher risk than those in other areas. In fact, it may pose a lower risk than in other areas. Unfortunately however, we could not find audited data from other areas, with complete leak records, for comparison.

One of the benefits of having data available which met various reporting standards was that incident rates could be established for a variety of criteria. For example, the California data could be used to establish incident rates for *all* leaks and injuries. Data from the other studies could be used to establish incident rates for their specific reporting criteria. These differences are summarized in the following subsection.

Table 3-5
California Regulated Hazardous Liquid Pipeline Data - All Leaks
1981 through 1990

	1981	1982	1983	1984	1985	1986
Total Pipeline Mileage	6,482	6,658	6,675	6,835	7,005	7,501
Number of Incidents	53	83	53	30	45	46
Incident Rate (Incidents/1,000 Mile Years)	8.18	12.47	7.94	4.39	6.42	6.13
Number of Injuries	0	1	2	0	0	15
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.150	0.300	0.000	0.000	2.000
Number of Fatalities	0	0	0	0	0	1
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.000	0.000	0.000	0.133

	1987	1988	1989	1990	Total
Total Pipeline Mileage	7,587	7,600	7,609	7,610	71,563
Number of Incidents	60	52	42	43	507
Incident Rate (Incidents/1,000 Mile Years)	7.91	6.84	5.52	5.65	7.08
Number of Injuries	0	0	31	0	49
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.000	4.074	0.000	0.685
Number of Fatalities	0	0	2	0	3
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.263	0.000	0.042

Note: The above table includes all leaks, regardless of size or severity.

California Regulated Hazardous Liquid Pipeline Data
Leaks Greater Than 5 Barrels, or Greater Than $5,000 Damage
1981 through 1990

	1981	1982	1983	1984	1985	1986
Total Pipeline Mileage	6,482	6,658	6,675	6,835	7,005	7,501
Number of Incidents	52	73	44	30	41	40
Incident Rate (Incidents/1,000 Mile Years)	8.02	10.96	6.59	4.39	5.85	5.33
Number of Injuries	0	1	2	0	0	15
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.150	0.300	0.000	0.000	2.000
Number of Fatalities	0	0	0	0	0	1
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.000	0.000	0.000	0.133

	1987	1988	1989	1990	Total
Total Pipeline Mileage	7,587	7,600	7,609	7,610	71,563
Number of Incidents	48	42	35	36	441
Incident Rate (Incidents/1,000 Mile Years)	6.33	5.53	4.60	4.73	6.16
Number of Injuries	0	0	31	0	49
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.000	4.074	0.000	0.685
Number of Fatalities	0	0	2	0	3
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.263	0.000	0.042

Note: The above table also includes all leaks which resulted in any injury, regardless of severity, and all leaks resulting in fatalities.

California Regulated Hazardous Liquid Pipeline Data
Leaks Greater Than $50,000 Damage
1981 through 1990

	1981	1982	1983	1984	1985	1986
Total Pipeline Mileage	6,482	6,658	6,675	6,835	7,005	7,501
Number of Incidents	39	56	33	20	31	27
Incident Rate (Incidents/1,000 Mile Years)	6.02	8.41	4.94	2.93	4.43	3.60
Number of Injuries	0	1	2	0	0	15
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.150	0.300	0.000	0.000	2.000
Number of Fatalities	0	0	0	0	0	1
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.000	0.000	0.000	0.133

	1987	1988	1989	1990	Total
Total Pipeline Mileage	7,587	7,600	7,609	7,610	71,563
Number of Incidents	34	30	21	26	317
Incident Rate (Incidents/1,000 Mile Years)	4.48	3.95	2.76	3.42	4.43
Number of Injuries	0	0	31	0	49
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.000	4.074	0.000	0.685
Number of Fatalities	0	0	2	0	3
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.263	0.000	0.042

California Regulated Hazardous Liquid Pipeline Data
Leaks Greater Than $500,000 Damage
1981 through 1990

	1981	1982	1983	1984	1985	1986
Total Pipeline Mileage	6,482	6,658	6,675	6,835	7,005	7,501
Number of Incidents	36	50	30	19	28	21
Incident Rate (Incidents/1,000 Mile Years)	5.55	7.51	4.49	2.78	4.00	2.80
Number of Injuries	0	1	2	0	0	15
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.150	0.300	0.000	0.000	2.000
Number of Fatalities	0	0	0	0	0	1
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.000	0.000	0.000	0.133

	1987	1988	1989	1990	Total
Total Pipeline Mileage	7,587	7,600	7,609	7,610	71,563
Number of Incidents	31	24	18	24	281
Incident Rate (Incidents/1,000 Mile Years)	4.09	3.16	2.37	3.15	3.93
Number of Injuries	0	0	31	0	49
Injury Rate (Injuries/1,000 Mile Years)	0.000	0.000	4.074	0.000	0.685
Number of Fatalities	0	0	2	0	3
Fatality Rate (Fatalities/1,000 Mile Years)	0.000	0.000	0.263	0.000	0.042

Note: The above tables also include all leaks which resulted in any injury, regardless of severity, and all leaks resulting in fatalities.

Table 3-6
Comparison of Various Incident Data Sources
All Data Presented In Incidents Per 1,000 Mile Years

|	Incident Rate	Injury Rate	Fatality Rate
CONCAWE - 1991 to 1989	1.000	0.010	0.030
U.S. Natural Gas - 1970 to 1984	1.300	0.096	0.016
U. S. Natural Gas - 1984 to 1988	0.270	0.062	0.015
U. S. Hazardous Liquid - 1986 to 1989	1.300	0.177	0.018
California (all leaks) - 1981 to 1990	7.080	0.685	0.042
California (leaks > 5bbl, or > $5,000) - 1981 to 1990	6.162	0.685	0.042
California Leaks (> $50,000) - 1981 to 1990	4.430	0.685	0.042
California Leaks (> $500,000) - 1981 to 1990	3.927	0.685	0.042

Incident Rate Comparison
Incidents Per 1,000 Mile Years
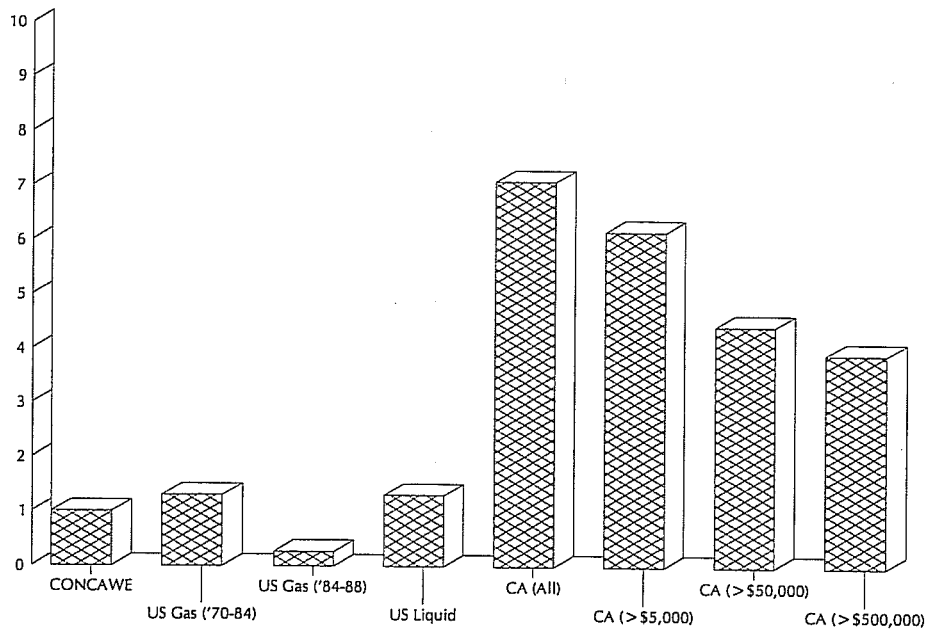
Note: The California data included all leaks and injuries, regardless of severity. Further, the California data was the only completely audited data sample represented. The resulting higher California incident rates do not necessarily indicate that California hazardous liquid pipelines pose a higher risk than those included in other studies. The reader should consult the report text for a more complete discussion.
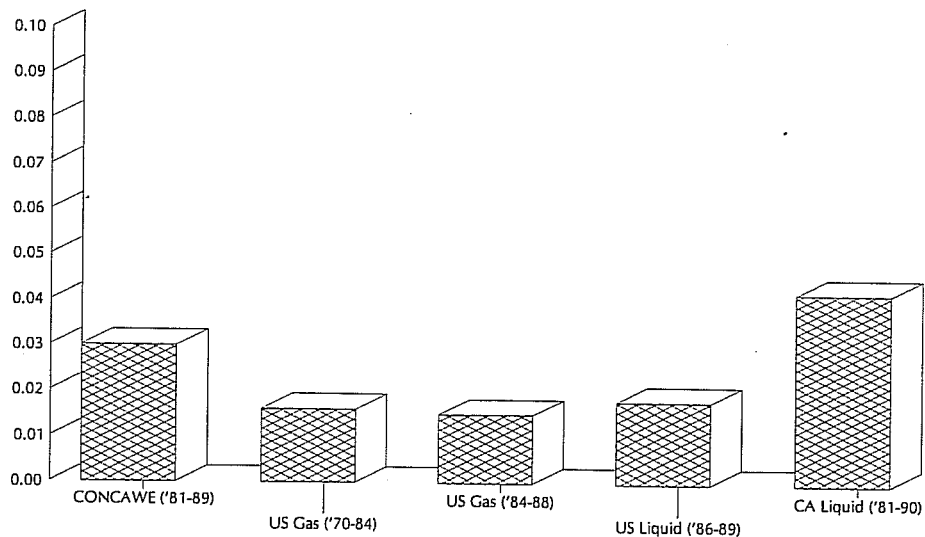
Injury Rate Comparison
Injuries Per 1,000 Mile Years
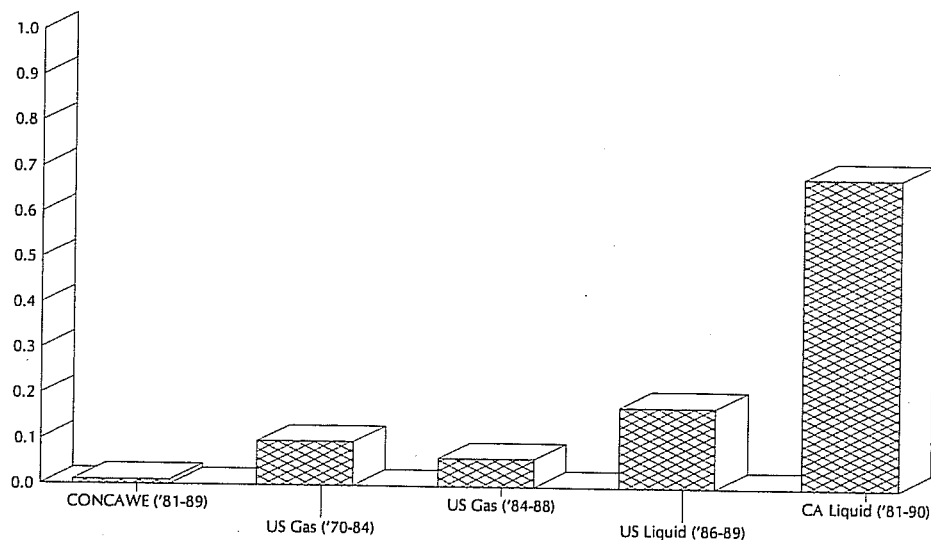
Fatality Rate Comparison
Fatalities Per 1,000 Mile Years

Note: The California data included all leaks and injuries, regardless of severity. Further, the California data was the only completely audited data sample represented. The resulting higher California incident rates do not necessarily indicate that California hazardous liquid pipelines pose a higher risk than those included in other studies. The reader should consult the report text for a more complete discussion.

3.7 Uncorrected Pipeline Risks

Using the data developed in the prior subsections, one can estimate the incident rates for various pipeline events as follows:

Event	Incident Rate
any size leak	7.1 incidents per 1,000 mile years
property damage greater than $5,000	1.3 to 6.2 incidents per 1,000 mile years
property damage greater than $50,000	up to 4.4 incidents per 1,000 mile years
any injury	0.70 injuries per 1,000 mile years
injury requiring hospitalization	0.10 injuries per 1,000 mile years
fatality	0.02 to 0.04 fatalities per 1,000 mile years

These values may be useful when evaluating the risks associated with proposed pipeline projects. In most cases, these values would represent the upper limit of any increased risk for new projects. As we will see in subsequent sections of this report, new lines, with modern external coatings and adequate cathodic protection systems generally have much lower leak incident rates.